Activity patterns of American black bears in Yosemite National Park

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Abstract: The impacts of tourism, most notably food resource enrichment and harassment, have led to alterations in natural bear (*Ursus* sp.) behavior in many National Parks throughout the United States. Comprehensive efforts to reduce these impacts and restore natural activity patterns have been elements of US National Park management for decades. We described black bear (*U. americanus*) activity patterns during 2001 and 2002 to assess the influence of human activity centers on bear behavior in Yosemite National Park, California, USA. We found bear activity and movement patterns, habitat use, and the distance bears were located from developed areas continued to be influenced by human presence in the Yosemite Valley region of Yosemite National Park. We recommend continued use of educational campaigns, stronger law enforcement efforts, improvements to food storage containers, more effective waste management, and more aggressive aversive conditioning techniques to reduce the number of human–bear interactions and restore the natural behavioral elements of Yosemite's black bear population.

Key words: activity patterns, American black bear, anthropogenic activity, California, distance to development, habitat use, movement patterns, tourism, *Ursus americanus*, Yosemite National Park

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Interactions between humans and bears are significant management concerns throughout the National Park system in the United States (Harms 1980, Tate and Pelton 1983, Gniadek and Kendall 1998, Gunther and Hoekstra 1998, Schirokauer and Boyd 1998). Conflicts between humans and American black bears (*Ursus americanus*) are caused frequently by the availability of human food and garbage to bears (Graber 1981, Tate and Pelton 1983, Hastings et al. 1989, Mattson 1990, Peine 2001). As in other regions of the US (Beeman and Pelton 1980, Blanchard and Knight 1991, Beckmann and Berger 2003), the relationship between bears and humans in Yosemite National Park has led to alterations in the natural behavior (Hastings et al. 1981), foraging habits (Graber 1981, Graber and White 1983), reproductive rates, physical size, distribution, and population levels of black bears in the park (Harms 1977, Graber 1981, Keay 1995).

Thompson and McCurdy (1995) presented an overview of past and current management of black bears in Yosemite National Park. Between 1960 and 1993, human injuries related to human–bear interactions declined, but the total number of interactions remained high (Thompson and McCurdy 1995). Property damage also increased during the period, with vehicle damage representing the largest proportion of bear-caused damage.

The National Park Service initiated the Human–Bear Management Program in Yosemite in 1975 to address continuing negative human and black bear interactions (National Park Service 1975, Thompson and McCurdy 1995, National Park Service 2003). Goals of the program included restoring and maintaining the natural distribution, abundance, and behavior of the black bear population; providing for the safety of visitors and their property; and providing opportunities for visitors to understand, observe, and appreciate black bears in their natural habitat. Thompson and McCurdy (1995) described the reactive and proactive management

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techniques used to achieve these goals, including the capture, relocation, and killing of bears; public information and education efforts; the removal of unnatural food sources; and the enforcement of regulations.

Thompson and McCurdy (1995) identified critical funding limitations restricting further management action. In 1999, Yosemite National Park began receiving an annual congressional appropriation of $500,000 to address human–bear interactions. These funds have been put toward each recommended action suggested by Thompson and McCurdy (1995), including the installation of bear-resistant food-storage containers and increased enforcement of their use, increased frequency of garbage pick-up, enlarged distribution system of bear-resistant food canisters used by backpackers, improvements to information and education materials, and increased staffing levels.

The goal of our research was to describe black bear activity patterns to assess the influence of human activity centers on bear behavior in the valley. We assessed activity and movement patterns, habitat use, and distances bears were located from developed areas in the valley and compared them to results from bear populations in less human-impacted areas.

Study area

Yosemite National Park encompasses approximately 308,000 ha on the west slope of the Sierra Nevada range in central California. Our research was conducted in approximately 1,800 ha of Yosemite Valley. The vegetation of the valley is primarily mixed conifer, with a prevalence of ponderosa pine (*Pinus ponderosa*), incense cedar (*Calocedrus decurrens*), and California black oak (*Quercus kelloggii*) (Barbour and Major 1977).

Although the valley comprises <1% of the total area of Yosemite, it receives 90% of the nearly 3.5 million people who visit the park annually (Keay and Webb 1989, National Park Service 2004). Approximately 45% of the Park's nearly 2,000 campsites and most of the 1,600 lodging units for park visitors and employees are located in the valley. Additionally, 62% of human–bear conflicts documented in the park between 1989 and 2002 occurred in Yosemite Valley (Matthews et al. 2003).

Methods

We trapped bears in the valley 3 July–17 November 2001 and 25 April–18 August 2002. Culvert traps and Aldrich foot snares were used in 69 locations for a total of 1,316 trap nights. Trap locations were selected based on reported bear activity, effective coverage of the valley, road availability, and access. Bears were immobilized using 4.3 mg/kg ketamine and 2.1 mg/kg xylazine. Each bear was marked with colored and uniquely numbered Allflex (Allflex International, Palmerton North, New Zealand) and Dalton Jumbo Tag (Dalton Supplies, New South Wales, Australia) ear tags. Each captured bear was equipped with a radiotransmitter (Model 405 or 505, Telonics, Mesa, Arizona, USA). A first upper premolar was collected from each captured bear for cementum annuli age determination (Matson's Laboratory LLC, Milltown, Montana). Bears that were at least 4 years old were classified as adults. The 4-year threshold was based on research documenting age at first reproduction in Yosemite National Park (Keay 1995).

Telemetry effort

We used ground-based telemetry techniques 9 July–15 November 2001 and 3 April–12 December 2002 to collect locations on radiocollared bears. Telemetry locations were collected from 2 or more locations using the loudest-signal method to determine azimuths (Springer 1979) using either a TR5 (Telonics, Mesa, Arizona, USA) or R1000 (Communications Specialists, Inc., Orange, California, USA) handheld receiver and a 4-element RA-14 antenna (Telonics, Mesa, Arizona, USA). Radiotelemetry error was determined using the location error method (Zimmerman and Powell 1995). Bearing angles were >20 degrees and the mean bearing distance was <400 meters. Location error was measured as the distance between an estimated location and the actual location of a test collar. Telemetry error was calculated as the average location error plus 2 standard deviations.

Our ground-based telemetry efforts were restricted primarily to the valley because of limited road availability beyond its borders. Aerial telemetry was used to supplement ground-based telemetry efforts. Aerial telemetry data was used only to generate home range estimates of radiocollared bears and were not used in any other analyses. We used a Cessna 182, a model 1000 radio receiver (Advanced Telemetry Solutions, Inc., Isanti, Minnesota, USA), and 4-element Yagi antennas (Advanced Telemetry Solutions, Inc., Isanti, Minnesota, USA) for aerial telemetry. Seventeen aerial telemetry flights were conducted 20 April–12 December 2002 at intervals of 10–20 days.

Activity patterns

We assessed bear activity patterns and movements in the valley using 24-hour monitoring events. A monitoring event was conducted each week between 7 August and 29 October 2001 and between 15 May and 15 October 2002. One radiocollared bear was tracked during each monitoring event. We selected a bear from 1 of the 4 age–sex classes based on the presence of each individual in the valley and the number of monitoring events completed on each individual. We systematically selected which age–sex class was to be sampled on a 4-week interval. We attempted to conduct an equal number of monitoring events for each age–sex class on as many radiocollared bears as possible. However, we were limited by the number of radiocollared bears in each class and variations in the length and timing of the presence of individual bears in the valley.

To document 24-hour bear activity patterns, we monitored radiocollared bears using radiotelemetry signals recorded for 30 seconds at 15-minute intervals. Fifteen of the 19 radiocollars were equipped with a reset switch, which activated a motion sensor in the transmitter causing an increase in pulse rate. An increased pulse rate indicated the collared animal was moving. We also used signal modulation (i.e., changes in the tone or strength of the radio signal) in conjunction with pulse rate for collars equipped with a reset switch (and exclusively for those collars without a reset switch) to determine bear activity (Ayres et al. 1986). We classified any change in signal modulation or a fast pulse rate within a 30-second window as an indication of active status. Locations of the monitored bear were recorded at 1-hour intervals during each 24-hour period using the above triangulation methods.

We calculated the proportion of time bears of each age–sex classes were active for each hour of a 24-hour period. Hourly activity was calculated by dividing the number of active readings by the total number of readings. Proportions of hourly activity were plotted for each age–sex class to identify patterns in activity throughout a 24-hour period.

We also determined black bear activity levels during diurnal and nocturnal periods. Diurnal and nocturnal periods were based on civil twilight (US Naval Observatory 2003). The 15-minute activity readings were pooled into 1-hour intervals. We used a 0.50 or greater threshold within each 1-hour interval as an indication of active status. The active proportion of each diurnal and nocturnal period was calculated by dividing the number of hourly active readings by the total number of readings. Diurnal and nocturnal activity patterns were determined for each age–sex class. *G*-tests were used to test the null hypothesis that bears were equally active during diurnal and nocturnal periods.

We also quantified activity patterns during periods in which bears where near or far from developed areas in the valley. Developed areas included any anthropogenic feature in the valley which was in use during 2001 and 2002, excluding roads and trails. These included parking lots, campgrounds, lodging facilities, employee housing, picnic areas, visitor center areas, and roadside turnouts with trash cans. Each 24-hour monitoring event was classified based as one in which the monitored bear was near a defined developed area or not. We arbitrarily defined near as the distance of our telemetry error (132 m). We determined proportions of activity when bears were near defined developed areas and when they were not located near developed areas. *G*-tests were used to test the null hypothesis that bears were equally active during diurnal and nocturnal periods when they were near developed areas and when they were not located near developed areas.

Movement patterns

We quantified bear movement patterns by measuring the distance traveled between 2 locations collected at approximately 1-hour intervals during a monitoring event. Movements were calculated in straight-line meters moved per hour using a geographic information system (GIS, ArcView 3.2, Environmental Systems Research Institute, Inc., Redlands, California, USA). Mann-Whitney *U*-tests were used to test the null hypothesis for each age–sex class that bears traveled equal distances during diurnal and nocturnal periods.

Habitat use

We quantified black bear habitat use within the valley to determine if bear use of developed habitats was in proportion to its availability. The generation of vegetation polygons for GIS applications was based on vegetation interpretation and mapping using California Wildlife Habitat Relationship (CWHR) classification scheme of 1:15,840 1997 aerial photography (Mayer and Laudenslayer 1988, NatureServe 2003). For our analyses we combined CWHR classes into 5 vegetation groups: (1) hardwood forest and chaparral, consisting of montane chaparral and montane hardwood, (2) coniferous forest, consisting of Jeffery pine (*Pinus jeffreyi*), ponderosa pine, red fir (*Abies magnifica*), white fir (*Abies concolor*), and Sierran mixed conifer, (3) riparian and grasslands: montane riparian, wet meadow, fresh emergent wetland, lacustrine, and annual grassland, (4) barren: non-vegetated rock, and (5) developed: human facilities, including parking lots, campgrounds, lodging

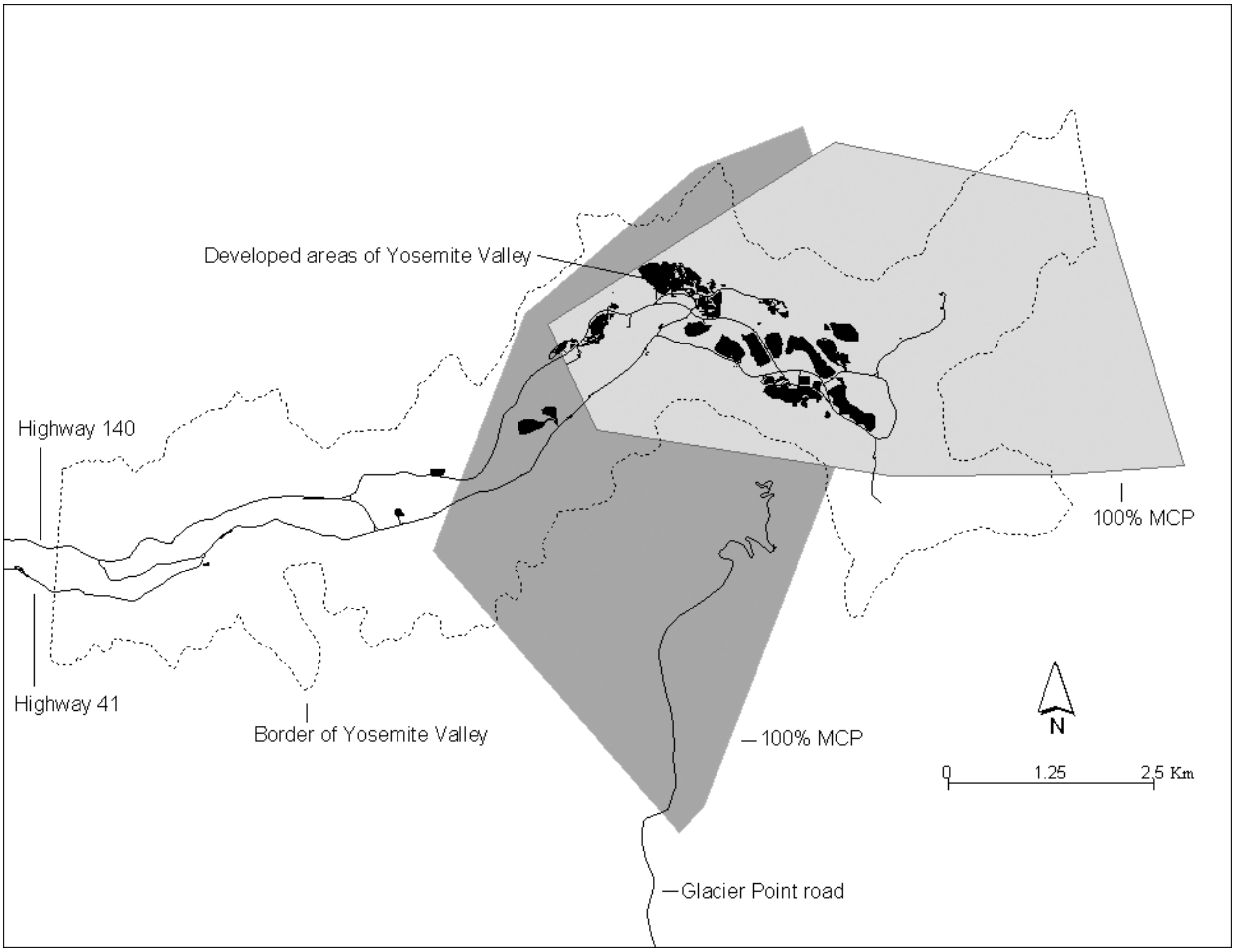

Fig. 1. Two sample 100% minimum convex polygons (MCP) constructed from telemetry locations collected on 2 black bears showing their relationship to the developed areas of Yosemite Valley, Yosemite National Park, California, 2001–02.

facilities, employee housing, picnic areas, visitor center areas, and roadside turnouts with trash cans.

We compared used to available habitat within the valley using compositional analysis at 2 levels: (1) vegetation composition within bear home ranges versus vegetation composition within the valley (Johnson's second-order selection [Johnson 1980], and (2) vegetation composition of individual bear locations versus vegetation composition of the bear home ranges (Johnson's third-order selection; Johnson 1980, Aebischer et al. 1993). Boundaries of the valley were defined following the 1,800 m elevation criteria outlined by Graber and White (1983) on the north and south boundaries. The eastern and western boundaries were based on generally accepted boundaries of the valley by park managers: 2.25 km northeast of Mirror Lake and 0.5 km west of Pohono Bridge. We used 100% MCP (minimum convex polygons) home range estimates to describe the outer limits of the movements of each bear (Mohr 1947, Aebischer et al. 1993, Fig. 1). We calculated habitat composition in the valley and the area of each bear's MCP which overlapped the valley using the above 5 habitat classes and a GIS.

We determined proportional habitat use within the valley for each radiocollared bear using ground-based radiotelemetry efforts conducted 9 July–15 November 2001 and 3 April–12 December 2002. The independence of individual bear relocations was not an issue using compositional analysis because individual bears were treated as the experimental unit (Aebischer et al. 1993, Erickson et al. 2001). Rather than determining an interval between sampling that was statistically in-

Table 1. Diurnal and nocturnal activity of radiocollared black bears recorded during 24-hour monitoring events in Yosemite Valley, Yosemite National Park, California, 7 Aug–29 Oct 2001 and 15 May–15 Oct 2002.

				Hourly activity readings		Activity (%)	
Age class	Sex	Radiocollared bears	24-hour monitoring periods	Diurnal	Nocturnal	Diurnal	Nocturnal
Adult	Male	5	8	117	85	21	61
	Female	4	8	125	74	49	62
Subadult	Male	2	5	71	52	51	58
	Female	2	7	104	65	63	65

dependent, we systematically sampled animal locations at >6 hour intervals, which we believed accurately estimated bear spatial distributions during the our sampling period (Kernohan et al. 2001). We buffered each bear location by an error circle with a radius equal to our telemetry error. We used the habitat composition of each error circle to determine the proportional habitat use of each radiocollared bear.

We replaced a value of 0% corresponding to a non-utilized but available habitat type with 0.1% (Aebischer et al. 1993). We used ReSelect (Resource Selection Analysis Software, http://ces.iisc.ernet.in/hpg/envis/resdoc1120.html) for compositional analyses.

Distance from development

We measured straight-line distances bears were located from developed areas of the valley using GIS. Distances each age–sex class were located from developed areas were tested for significant differences using a Kruskal-Wallis 1-way ANOVA and a Kruskal-Wallis multiple-comparison procedure (Kruskal-Wallis MCP) with a Bonferroni correction. Distances bears were located from developed areas during diurnal and nocturnal periods and active and inactive periods were tested for significant differences using Mann-Whitney *U*-tests. Bear locations were also compared to random locations generated from the uniform random distribution using a Mann-Whitney *U*-test. Significance for all tests was determined using $\alpha = 0.10$.

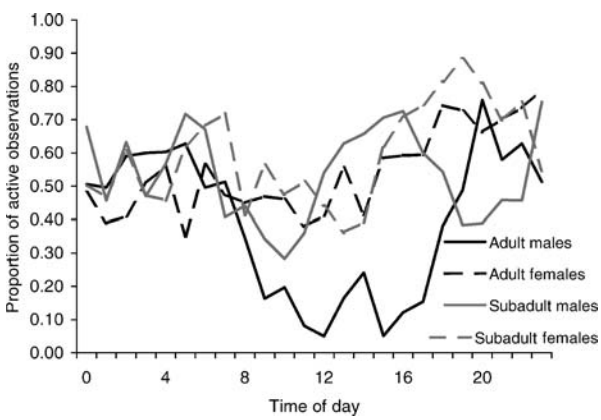

Fig. 2. Hourly activity patterns of adult male ($n = 8$), adult female ($n = 8$), subadult male ($n = 5$), and subadult female ($n = 7$) black bears during 24-hour monitoring events in Yosemite Valley, Yosemite National Park, California, 7 Aug–29 October 2001 and 15 May–15 October 2002.

Results

Twenty-two bears were captured a total of 50 times between 2001 and 2002. The 22 captured bears included 10 adult males, 6 adult females, 3 subadult males, and 3 subadult females. Of these, 9 adult males, 6 adult females, 2 subadult males, and 2 subadult females were fitted with radiocollars. One adult male was euthanized as a result of a capture-related injury. One subadult female and one subadult male were not radiocollared due to their small size. Two adult males dropped their collars approximately 4 and 6 weeks after capture. One radiocollared subadult male was killed by California Department of Fish and Game personnel outside the park for management reasons in spring 2002.

Telemetry effort

The average location error was 55.6 m with a standard deviation of 38.2 m. This yielded a telemetry error of 132 m (the location error plus 2 standard deviations).

Activity patterns and movement

Twenty-eight 24-hour monitoring events were completed on 13 bears during the 2001 and 2002 seasons (Table 1). Adult males exhibited an apparent unimodal pattern of activity (Fig. 2). Increases in adult male activity usually started around 1700 and remained high until 0500, when activity levels declined throughout the morning. Hourly activity patterns of adult female, subadult female, and subadult male bears were similar

Table 2. Diurnal and nocturnal activity of radiocollared black bears during 24-hour monitoring events in natural and developed areas in Yosemite Valley, Yosemite National Park, California, 7 Aug–29 Oct 2001 and 15 May–15 Oct 2002. Monitored adult and subadult males used developed areas of Yosemite Valley during each of the 24-hour monitoring events. Thus we were unable to determine activity patterns of adult and subadult males when they used only natural areas.

					Hourly activity readings		Activity (%)	
Age class	Sex	Location	Radiocollared bears	24-hour monitoring periods	Diurnal	Nocturnal	Diurnal	Nocturnal
Adult	Male	Developed	5	8	117	85	21	61
	Female	Natural	2	3	43	24	79	29
		Developed	4	5	82	50	34	72
Subadult	Male	Developed	2	5	71	52	51	58
	Female	Natural	2	5	74	46	66	57
		Developed	1	2	30	19	53	84

to each other. Each of these classes exhibited periods of activity and inactivity throughout a 24-hour period (Fig. 2).

Adult male bears were significantly more active during nocturnal than diurnal periods ($\chi^2 = 20.3$, 1 df, $P < 0.001$, Table 1). The activity patterns of adult female, subadult male, and subadult female bears were not significantly different between diurnal and nocturnal periods (all 3 tests $\chi^2 \leq 1.3$, 1 df, $P \leq 0.249$, Table 1). Proportions of activity for the different age and sex class ranged from 21 to 63% and from 58 to 65% during diurnal and nocturnal periods, respectively (Table 1).

Monitored adult and subadult males were near developed areas of the valley during each of the 24-hour monitoring events. Thus we were unable to determine activity patterns of adult and subadult males when they were only in natural areas. Monitored adult females were located far from developed areas during 5 monitoring events and never entered our category of "near developed areas" during 3 monitoring events (Table 2). We found when adult females were located only in natural areas they were more active during diurnal than nocturnal periods ($\chi^2 = 7.1$, 1 df, $P = 0.008$, Table 2). Alternatively, when adult females were near developed areas they were more active during nocturnal periods than diurnal periods ($\chi^2 = 8.8$, 1 df, $P = 0.003$). Monitored subadult females were located near developed areas during 2 monitoring events and were located only in natural areas during 5 monitoring events (Table 2). When subadult females were located only in natural areas, there was a trend toward being more diurnal and when they were near developed areas they were generally more nocturnal; however, these results were not significant ($\chi^2 < 1.7$, 1 df, $P > 0.198$).

Seven hundred and eight hourly movement distances were collected on 13 bears over 28 24-hour monitoring events (Table 3). Adult male and adult female bears moved significantly greater distances during nocturnal periods than during diurnal periods ($Z \geq 3.39$, df ≥ 205, $P \leq 0.001$). Subadult male and subadult female bears did not move significantly different distances during the 2 periods ($Z \leq 0.33$, df ≥ 116, $P \geq 0.742$).

Habitat use

Five hundred and sixty-six telemetry locations were collected and used to determine habitat use of black bears in the valley during the 2001 and 2002 seasons. The overall analysis of habitat use from MCP ranges compared to habitat availability in Yosemite Valley resulted in Wilks' lambda statistic (Λ) = 0.1663 ($\chi^2 = 23.32$, 4 df, $P < 0.001$, Table 4). Thus, bears did not establish home range areas within the valley at random.

Table 3. Diurnal and nocturnal movements of radiocollared black bears during 24-hour monitoring events in Yosemite Valley, Yosemite National Park, California, 7 Aug–29 October 2001 and 15 May–15 Oct 2002.

				Hourly movement observations		Movement distances (SE) (meters/hour)	
Age class	Sex	Radiocollared bears	24-hour monitoring periods	Diurnal	Nocturnal	Diurnal	Nocturnal
Adult	Male	5	8	131	90	181 (29)	365 (35)
	Female	4	8	137	70	272 (29)	410 (40)
Subadult	Male	2	5	66	52	265 (41)	237 (47)
	Female	2	7	97	65	305 (34)	295 (42)

Table 4. Percent habitat availability within Yosemite Valley and average percent habitat use based on minimum convex polygon (MCP) home range estimates and radiotelemetry locations of black bears in Yosemite Valley, Yosemite National Park, California, 2001–02.

Habitat type	Percent of Yosemite Valley	Average percent habitat use based on MCP home range estimates	Average percent habitat use based on radiotelemetry locations
Hardwood–chaparral	44.2	35.7	37.4
Coniferous forest	27.3	31.4	34.0
Riparian–grasslands	8.5	11.2	10.2
Barren	16.1	13.9	5.6
Developed	3.9	7.7	11.6

A ranking matrix ordered habitat types by use in the following sequence: developed > riparian and grasslands > coniferous forest > barren > hardwood forest and chaparral (Table 5). There was no detectable difference in use of developed and riparian–grassland habitats, but each was used significantly more than the remaining habitat types. Coniferous forest was used significantly less than developed and riparian–grassland habitats and significantly more than barren and hardwood forest–chaparral habitats. There was no detectable difference in use of barren and hardwood forest–chaparral habitats.

The analysis of habitat use based on habitat composition immediately surrounding radiolocations compared to habitat availability in each MCP resulted in $\Lambda = 0.2317$ ($\chi^2 = 19.01$, 4 df, $P < 0.001$, Table 4). Thus, bears were not located at random within their home ranges. A ranking matrix ordered the habitat types by frequency of use in the following sequence: developed > coniferous forest > hardwood forest–chaparral > riparian–grasslands > barren (Table 6). There was no detectable difference in use of the 4 top-ranking habitats, but each was used significantly more than barren habitat.

Distance from development

Five hundred and sixty-six telemetry locations were collected and used to determine the distance bears were located from developed areas of the valley during 2001 and 2002 (Table 7). Significant differences were found in the distances each age–sex class were located from developed areas ($H = 25.31$, 3 df, $P < 0.001$). Subadult male bears were found significantly closer to developed areas than bears in the other age–sex classes ($Z \geq 3.49$, 3 df, $P = 0.05$). No significant differences in the distances bears were located from developed areas were found between adult male, adult female, and subadult female bears.

Bears also were located closer to developed areas during nocturnal periods ($\bar{x} = 107$ m, SE = 11 m) than during diurnal periods ($\bar{x} = 238$ m, SE = 8 m, $Z = 3.90$, 564 df, $P < 0.001$). Additionally, bears were located closer to developed areas during periods of activity ($\bar{x} = 187$ m, SE = 11 m) than during periods of inactivity ($\bar{x} = 226$ m, SE = 9 m, $Z = 3.90$, 564 df, $P < 0.001$). Each age–sex class was located significantly closer to developed areas than expected ($Z \geq 6.02$, df ≥ 81, $P < 0.001$).

Discussion

Yosemite National Park personnel, under the direction of the Human–Bear Management Program, have made efforts to restore and maintain the natural ecology of Yosemite's black bear population. However, some elements of black bear activity in Yosemite Valley continue to differ from that of bears in more wild settings. These differences were probably functional responses to the presence of humans through food resource enrichment and harassment and the proximity of highly used, natural habitats.

Table 5. Ranking matrix for bears generated by comparing proportional habitat use within minimum convex polygon (MCP) home range estimates with proportions of habitat availability in Yosemite Valley, Yosemite National Park, California, 2001–02. A triple sign represents significant deviation from random at $P < 0.10$. A single sign represents a non-significant difference in use ($P > 0.10$).

	Habitat type					
Habitat type	Hardwood–chaparral	Coniferous forest	Riparian–grasslands	Barren	Developed	Rank
Hardwood–chaparral		− − −	− − −	−	− − −	0
Coniferous forest	+ + +		− − −	+ + +	− − −	2
Riparian–grasslands	+ + +	+ + +		+ + +	−	3
Barren	+	− − −	− − −		− − −	1
Developed	+ + +	+ + +	+	+ + +		4

Table 6. Ranking matrix for bears generated by comparing proportional habitat use based on radio telemetry locations with proportions of total available habitat types within minimum convex polygon (MCP) home range estimates in Yosemite Valley, Yosemite National Park, California. A triple sign represents significant deviation from random at $P < 0.10$.

	Habitat type					
Habitat type	Hardwood–chaparral	Coniferous forest	Riparian–grasslands	Barren	Developed	Rank
Hardwood–chaparral		−	+	+ + +	−	2
Coniferous forest	+		+ + +	+ + +	−	3
Riparian–grasslands	−	− − −		+ + +	−	1
Barren	− − −	− − −	− − −		− − −	0
Developed	+	+	+	+ + +		4

Our results indicated that human activity and use of developed areas in the valley by bears result in behavioral differences between bears in the valley and bears in areas with less human impact. Black bears were mostly diurnal in natural environments in Idaho (Amstrup and Beecham 1976), Washington (Lindzey and Meslow 1977), Tennessee (Garshelis and Pelton 1980), California (Ayres et al. 1986), and Québec (Larivière et al. 1994). Bacon and Burghardt (1976) and Larivière et al. (1994) argued that diurnal patterns of bears could be explained by foraging behavior. Bears rely on visual cues and may be more efficient foraging during daylight hours. Bears found foraging in campgrounds have demonstrated nocturnal behavior, most likely to minimize the chance of human harassment (Ayres et al. 1986, Larivière et al. 1994, Pelton 2000). Ayres et al. (1986) argued that human intervention through food resource enrichment and harassment prompted a transition to nocturnal behavior by bears in Sequoia National Park. Our findings in the valley support those of Ayres et al. (1986) and provide further evidence for behavioral plasticity in black bears and the impact of recreational-use pressure on the activity patterns of bears. The nocturnal activity patterns of adult male bears in our study probably resulted from their consistent proximity to developed areas in the valley. Subadult male bears also were consistently located near developed areas, but did not exhibit significant nocturnal activity patterns. A lack of significant nocturnal activity despite consistent proximity to developed areas by subadult males could have been the result of inexperience, competitive exclusion by adult males, or both (Bunnell and Tait 1981, Young and Ruff 1982, Rogers 1987, Mattson 1990).

Ayres et al. (1986) presented evidence for behavioral plasticity between individual black bears that used developed areas of Sequoia National Park and those that used only natural areas. Anecdotally, we found evidence for behavioral plasticity within individual bears in the valley based on whether they were near a developed area during monitoring. We found one adult female (bear 2394) in only natural areas during 2 monitoring events and near developed areas during 2 other monitoring events. When she was located in only natural areas, her probability of activity during diurnal periods was 0.90 and during nocturnal periods was 0.37. When she was near developed areas, her probability of activity during diurnal periods decreased to 0.45 and her probability of activity during nocturnal periods increased to 0.63.

We found similar results for one subadult female (bear 3032) that was located in only natural areas during 4 monitoring events and was near developed areas during 2 other monitoring events. When she was located only in natural areas, her probability of activity during diurnal periods was 0.66 and during nocturnal periods was 0.62. Alternatively, when she was near developed areas, her probability of activity during diurnal periods decreased to 0.53 and her probability of activity during nocturnal periods increased to 0.84. These data suggest that the shift in activity from diurnal to nocturnal periods was influenced by human activity and not ambient temperature as suggested by Garshelis (1978).

Natural habitats within the valley provided a number of the habitat requirements for black bears identified by

Table 7. Mean, standard error (SE), and range of distances (m) bears were located from developed areas of Yosemite Valley, Yosemite National Park, California, 9 Jul–15 Nov 2001 and 3 Apr–12 Dec 2002.

Age–sex class	*n*	Mean distance (m) from developed areas (SE)	Range of distance (m) from developed areas
Adult male	182	202 (12)	0–893
Adult female	208	223 (11)	0–771
Subadult male	82	135 (18)	0–882
Subadult female	94	244 (17)	0–915

Pelton (2000), including spring and summer feeding areas, fall sources of hard and soft mast, escape cover, and movement corridors. Graber (1981) identified the valley among the highest quality bear habitats in the park. He attributed consistent bear use of the valley to nutritious plant foods generally available during all months of bear activity. The coniferous forest, hardwood forest, and chaparral habitats in the valley provided areas of hard and soft mast crops, including California black oak, Himalayan blackberries (*Rubus discolor*), western raspberries (*Rubus* sp.), coffeeberry (*Rhamnus* spp.), manzanita (*Arctostaphylos* spp.), and apples. The riparian and grassland habitats provided herbage and other items for spring and summer feeding. Forested habitats provided escape and movement corridors for bears throughout the valley.

Our results indicated that subadult male bears were typically found closer to developed areas; this should make their management of special concern for park managers. Adult female and subadult male and female brown bears (*U. arctos*) have been documented to occupy areas nearer humans than do adult males (Mattson et al. 1987, Warner 1987, McLellan and Shackleton 1988). Subadult male brown bears comprised a large proportion of bears using campgrounds in Yellowstone National Park (Mattson 1990). Subadult male black bears comprised a large proportion of bears using small dumps near developed areas in Alberta (Tietje and Ruff 1983). Mattson (1990) argued that habitat selection by adult males, typically in areas of rich food resources away from development, competitively excludes adult female and subadult male bears from these areas, leaving them to forage in areas closer to development. He also argued that proximity to humans might serve as a refuge for subadult males from adult males.

The greater than expected presence of black bears near developed areas of the valley was probably a function of both food resource enrichment by humans and the presence of high quality natural foods near these developed areas. The valley receives nearly 3.5 million visitors annually (Keay and Webb 1989, National Park Service 2004). Additionally, 62% of the human–bear conflicts documented in the park between 1989 and 2002 occurred in the valley (Matthews et al. 2003). Ayres et al. (1986) observed that bears foraging only on natural food items and never visiting campgrounds tended to center their activity away from areas of high human use, even though real distance to campgrounds was small in Sequoia National Park.

Human influences, including food resource enrichment and harassment, have resulted in alterations of the behavior of black bears in the valley. Management efforts should continue to address issues related to both visitors and bears. Educational campaigns, stronger law enforcement efforts, improvements to food storage containers, more effective waste management, and more aggressive aversive conditioning continue to be promising methods to reduce human–bear interactions. These management tools should be consistently used and refined to ensure the restoration of the natural ecological elements of Yosemite's black bear population.

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